## Title

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# Prognostic Impact of the Timing of Recurrence of Infarct-Related Ventricular Tachycardia After Catheter Ablation

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## Abstract

**Background—**Recurrence of ventricular tachycardia (VT) after ablation in patients with previous myocardial infarction is associated with adverse prognosis. However, the impact of the timing of VT recurrence on outcomes is unclear.

**Methods and Results—**We analyzed data from a multicenter collaborative database of patients who underwent catheter ablation for infarct-related VT. Multivariable Cox regression analyses investigated the effect of the timing of VT recurrence on the composite outcome of death or heart transplantation using VT recurrence as a time-varying covariate. A total of 1412 patients were included (92% men; age: 66.7±10.7 years), and 605 patients (42.8%) had a recurrence after median 116 days (188 [31.1%] within 1 month, 239 [39.5%] between 1 and 12 months, and 178 [29.4%] after 12 months). At median follow-up of 670 days, 375 patients (26.6%) experienced death or heart transplantation. The median time from recurrence to death or heart transplantation was 65 and 198.5 days in patients with recurrence ≤30 days and >30 days post ablation, respectively. The adjusted hazard ratio (95% confidence interval) for the effect of VT recurrence

occurring immediately post ablation on death or heart transplantation was 3.45 (2.33–5.11) in reference to no recurrence. However, the magnitude of this effect decreased statistically significantly ($P<0.001$) as recurrence occurred later in the follow-up period. The respective risk estimates for VT recurrence at 30 days, 6 months, 1 year, and 2 years were 3.36 (2.29–4.93), 2.94 (2.09–4.14), 2.50 (1.85–3.37), and 1.81 (1.37–2.40).

**Conclusions—**VT recurrence post ablation is associated with a mortality risk that is highest soon after the ablation and decreases gradually thereafter.

### Keywords

catheter ablation; myocardial infarction; prognosis; recurrence; ventricular tachycardia

Catheter ablation of ventricular tachycardia (VT) may reduce implantable cardioverter defibrillator (ICD) shocks and improve quality of life,[1–3] but recurrence of VT after ablation is common and has been shown to be a strong predictor of mortality.[4] However, not all recurrences may confer the same prognostic impact. A previous single-center study indicated that VT recurrence within a few days after ablation is associated with an adverse outcome,[5] but it is unclear whether VT recurrences beyond the early postablation period affect survival to the same extent. The purpose of this study was to assess the impact of the timing of VT recurrence on prognosis in a large multicenter sample of patients who underwent VT ablation for infarct-related VT.

## Methods

### Study Population

Eligible patients were included from 8 centers with experience in VT ablation from the United States and Europe. The population in the current study is an extension of a previously published cohort,[6] with the inclusion of one additional VT ablation center and with additional patients and longer follow-up from all centers. All consecutive patients undergoing catheter ablation for infarct-related VT were eligible for inclusion. Patients either had a history of myocardial infarction or evidence of previous infarction as assessed by objective testing. Patients were included regardless of their left ventricular ejection fraction (LVEF), New York Heart Association (NYHA) class, history of antiarrhythmic medication use, or history of catheter ablation for VT.

### Mapping and Ablation

Details of the mapping and ablation procedure have been published previously.[6] Briefly, after informed consent was obtained, programmed stimulation was performed with ≤4 extra stimuli from multiple right ventricular locations with coupling intervals down to 200 ms or refractoriness, whichever occurred first, in an attempt to induce VT unless the patient was in VT at the beginning of the procedure. Clinical VT was defined on the basis of 12-lead electrocardiograms or VT electrogram morphology from ICD recordings. When these were unavailable, the tachycardia cycle lengths were used. A 3-dimensional mapping system and irrigated-tip catheters were used for mapping and ablation. Entrainment mapping was performed for hemodynamically tolerated VT with ablation at sites of concealed

entrainment, whereas ablation during sinus rhythm at sites with matching pace maps or fragmented electrograms or low-voltage electrograms was performed in hemodynamically unstable VT. Epicardial access for mapping and ablation was performed as needed. At the conclusion of the procedure, programmed stimulation was repeated from 2 ventricular sites with ≤4 extra stimuli. Procedural success was classified as complete when no sustained monomorphic VT was inducible, partial when only a nonclinical VT was inducible, and failed when the clinical VT was inducible at the end of the procedure. Programmed stimulation at the end of the procedure was performed at the discretion of the operating physician depending on the hemodynamic status of the patient. Postablation use of antiarrhythmic medications was individualized on a case-by-case basis, but certain general principles also applied. Antiarrhythmic medications were reduced in dosage or discontinued if no VTs were inducible after the ablation procedure, unless there was another indication for antiarrhythmic drug treatment such as atrial fibrillation. Antiarrhythmic drug therapy was continued in the absence of side effects if VT was still inducible or if programmed stimulation was not performed at the end of the procedure.

## Data Collection

Using standardized forms, individual patient data were requested from each center. We collected data on patient demographics, previous ablation procedures at other institutions, procedural characteristics, use of antiarrhythmic medications before the procedure and on discharge from the index hospitalization, and the dates of VT recurrence, heart transplantation (HTx), or death from any cause. The composite of death or HTx was the primary outcome. If a patient did not experience death or HTx, the date the patient was last known to be alive was documented. Recurrent VT was defined as sustained VT documented electrocardiographically or by ICD electrograms, regardless of whether ICD therapies were delivered and regardless of whether it was an original clinical VT or not. Follow-up data were obtained from clinic or emergency room visits, hospital admissions, and device interrogations or by contacting the referring physicians. Repeat ablation procedures performed in the same or other institutions were also documented.

## Statistical Analysis

The first procedure at the referral center was considered to be the index procedure in this analysis, and patients were followed up from the index procedure to death or HTx, whichever occurred earlier, or the most recent date the patient was known to be alive. VT recurrence occurred at varying time points during the follow-up period. Baseline patient demographic, clinical, and procedural characteristics were summarized for the overall population, for the subsets of patients with versus without a VT recurrence, and also for those who did and did not meet the end point of death or HTx. Categorical variables are reported as frequencies and percentages, whereas continuous variables are reported using medians and interquartile ranges (IQR). Bivariate associations between the potential covariates and VT recurrence were tested using Cox regression model with time from index ablation procedure to VT recurrence as the time variable and with each characteristic as a single predictor; bivariate associations with time from index ablation to death or HTx were similarly tested.

Cumulative incidence curves for the competing risks of VT recurrence and death or HTx in the overall population were constructed. A Cox regression model was used to assess whether VT recurrence was predictive of death or HTx, with VT as a time-varying covariate equal to 0 before recurrence and 1 afterward, while adjusting for other baseline covariates. Baseline variables considered for inclusion as covariates were those known or potentially known to be associated with VT recurrence or with death or HTx and included the following: age, sex, diabetes mellitus, atrial fibrillation, hypertension, dyslipidemia, chronic kidney disease, LVEF, NYHA class, previous ablation, ICD shock, VT storm, cardiac resynchronization therapy, and procedural success status. A stepwise selection approach was used to select covariates for inclusion in the multivariable model. Use of antiarrhythmic medications in the postablation period was not considered as a covariate because we did not have information on compliance and duration of use in the follow-up period after ablation. Because the hazard of death associated with VT recurrence may not be constant during the postablation follow-up time, we tested for the nonproportional hazards using an interaction of the time-varying VT recurrence by follow-up time (in days). Based on parameter estimates of the final Cox regression model, adjusted hazard ratios (HR) associated with VT recurrence occurring on different days after ablation were obtained along with their 95% confidence intervals (CI) with the following formula: HR on day t=(HR on day 0)×(HR per day)$^t$. Finally, we also assessed the effect of repeat ablations on death or HTx among patients with a VT recurrence by a separate Cox regression model. In this analysis, repeat ablation was a time-varying variable. Analyses were performed in Stata 14.0 (College Station, TX), and statistical significance was a priori set at 0.05. Institutional board review approval was obtained by all participating centers.

## Results

### Baseline Characteristics

A total of 1412 patients underwent index ablation procedures from 2004 to 2015 (92% men; mean age: 66.7±10.7 years). Two hundred and fifty patients (17.7%) had a previous ablation procedure before the index procedure. Median LVEF was 30% (IQR: 22%–40%), and 36% of the patients had advanced heart failure (NYHA class III–IV). Amiodarone use was common in the preprocedural period (59%).

At the onset of the ablation procedure, 11.4% of the patients had no inducible VT. The median procedural and radiofrequency ablation times were 219 minutes (IQR: 160–300) and 34 minutes (IQR 19.9–54.6), respectively. The median numbers of clinical and induced VTs were 1 (IQR: 1–1; range: 1–15) and 2 (IQR: 1–4; range: 0–23), respectively. Complete success was documented in 68.4% of patients, whereas the procedure failed to eliminate the clinical VT in 5.2% of the patients. Programmed stimulation was not performed at the end of the procedure in another 5.2% of the patients. Amiodarone was prescribed in 544 patients at discharge in 35.5% of the patients with complete procedural success versus 53.3% of the patients with partial success or procedural failure. Further details on baseline characteristics are shown in Table 1.

### VT Recurrence

A total of 605 patients (42.8%) had a VT recurrence, with median time from ablation to VT recurrence of 116 days (IQR: 19–435; Figure 1). Overall median follow-up was 670 days (IQR: 293–1057). Among all recurrences, the distribution of recurrences in the first 7, 30, 180, 365, and >365 days was 115 (19%), 188 (31.1%), 347 (57.4%), 427 (70.6%), and 178 (29.4%), respectively.

In univariate analyses, several statistically significant predictors of VT recurrence were identified, including diabetes mellitus, advanced heart failure (NYHA class III–IV), VT storm, and ICD shocks. Mean LVEF was also lower among patients who developed VT recurrence (Table 1).

Among procedural characteristics, the acute procedural outcome was a significant predictor of VT recurrence (Table 1). Among patients who developed a recurrence, 62.1% had a successful ablation procedure, and 31.9% had a partially successful or failed ablation procedure, whereas the respective rates in patients without recurrence were 72.8% and 22.7%. Finally, the use of class 1 antiarrhythmic medications and amiodarone at the time of discharge from the index hospitalization was higher in patients who had VT recurrence than in those who did not.

### Death and HTx

Information on survival was available for 1282 patients (90.8%), 1177 patients (83.4%), and 799 patients (56.6%) at 6 months, 1 year, and 2 years, respectively. A total of 24 patients (1.7%) had HTx and 356 patients (25.2%) died from any cause during the follow-up period (median of 670 days). The composite end point of death or HTx was met in 375 patients (26.6%), and the median time from ablation to death or HTx was 393 days (IQR: 86–815). Among all deaths or HTx, 15.5% occurred within 30 days post ablation, whereas 52% occurred >1 year post ablation (Figure 2).

By univariate analyses, age, diabetes mellitus, atrial fibrillation, chronic kidney disease, low LVEF, advanced NYHA class, cardiac resynchronization therapy, VT storm, and procedural failure were all significant predictors of death or HTx (Table 2). Amiodarone and class 1 antiarrhythmic medication use on discharge from the index hospitalization was more frequent among patients who experienced an end point, whereas sotalol was less frequently prescribed at discharge in patients who eventually experienced an end point.

### Timing of VT Recurrence and Outcomes

Among the 605 patients with VT recurrence, 190 patients (31.4%) experienced death or HTx, whereas among the 807 patients without VT recurrence, 185 (22.9%) experienced death or HTx. The median time from recurrence to death or HTx was 133.5 days (IQR: 14–562). Among the patients who experienced recurrence ≤30 days post ablation, the median time from recurrence to death or HTx was 65 days (IQR: 12–336), whereas it was 198.5 days (IQR: 21–658.5) among those who experienced recurrence >30 days after ablation.

In multivariable Cox regression model for time to death or HTx, VT recurrence, age, diabetes mellitus, atrial fibrillation, low LVEF, and procedural success status were found to

be significant predictors (Table 3). When tested for nonproportional hazards associated with VT recurrence over time, the effect of VT recurrence on HR was found to significantly decrease in time ($P$<0.001) by 0.9991175 (95% CI, 0.9986725–0.9995626) per day post ablation or by 0.973861 (95% CI, 0.9609322–0.9869609) per month post ablation. Based on this model, VT recurrence on day 0 after ablation conferred a HR of 3.45 (95% CI, 2.33–5.11) for death or HTx compared with no recurrence, with the risk associated with VT recurrence declining gradually from the HR of 3.45 at time 0 as the interval from ablation to VT recurrence increased (Figure 3). The HR estimates associated with VT recurrence at representative time points are shown in Table 3. Recurrence had a significant adverse effect on prognosis if it occurred up to day 1032, at which point the HR estimate for death or HTx was 1.39 (95% CI, 0.99–1.93).

### Effect of Repeat Ablations

Fifty-six (18.9%) of 296 patients with a VT recurrence underwent a repeat ablation at a median of 309 days (IQR: 145–781) after the index procedure and 87.5 days (IQR: 11.5–250) after the VT recurrence. There were no significant differences in baseline characteristics between patients who underwent a repeat ablation and those who did not. In addition, there was no difference in the time from the index ablation to VT recurrence between patients who underwent repeat ablation (median: 108 days) and those who did not (median: 139 days; $P$=0.70). Patients who underwent repeat ablation had a longer time from recurrence to death or HTx or last follow-up (median: 595.5 days [IQR: 148–1097]) compared with those who did not have repeat ablation (median: 147 days [IQR: 2–445]; $P$<0.001). The overall median time from index ablation to death or HTx or last follow-up among patients with and without repeat ablations was 791.5 days (IQR: 408–1406) and 619 days (IQR: 216–913), respectively ($P$<0.001). In a multivariable Cox regression model of the time from VT recurrence to death or HTx, after adjusting for age, sex, VT storm, LVEF, NYHA class, atrial fibrillation, chronic kidney disease, and procedural success status, the HR (95% CI) associated with repeat ablation was 0.46 (0.15–1.47).

## Discussion

In this large multicenter analysis with extended follow-up of patients undergoing ablation of infarct-related VT, recurrence of VT has a time-dependent impact on mortality or HTx that is independent of other examined risk factors. The highest risk is associated with recurrences occurring early after ablation, and the risk declines subsequently with later recurrences but continues for ≈3 years after the ablation procedure.

### VT Recurrence

Despite advances in VT mapping and ablation technologies, recurrence of VT after ablation remains one of the major challenges of VT ablation.[4] Several clinical variables, such as advanced age, poor LVEF, advanced NYHA class, and atrial fibrillation, and the inability to eliminate all VTs during the ablation procedure have been associated with recurrence, but it remains unknown whether these factors are causally related to the risk of recurrence or are simply markers of adverse outcome.[3,4,6,7] VT recurrence may be simply a reflection of a failed ablation procedure, especially if the recurrence occurs early after ablation. However,

patients can have recurrent VT despite an acutely successful ablation procedure. In a study in which recurrent VTs were characterized on the basis of ICD electrograms,[8] the reasons for VT recurrence were primarily the emergence of new VT circuits or recurrence of a clinical VT that was either noninducible or that was unsuccessfully ablated. Importantly, a significant proportion of the new VTs had critical areas in proximity to previous ablation lesions. Although these are some of the recognized mechanisms of VT recurrence after ablation, their relative contribution to early versus late recurrences remains unknown. The accurate characterization of recurrent VTs is a challenge because it requires the availability of detailed ICD electrograms or 12-lead ECG documenting the VT.[9]

## VT Recurrence and Mortality

Recurrence of VT after ablation is an independent predictor of all-cause mortality,[4,6] but the timing of VT recurrence and its impact on mortality have not been investigated previously. The rates of VT recurrence and mortality seem to run in parallel and are the highest within the first month post ablation. The relationship between early VT recurrence and increased risk of mortality may suggest a stronger contribution of arrhythmic mechanisms to deaths that occur early after ablation, but this is speculative. Although the availability of the causes of death in our study would be necessary to reach definite conclusions on this association, a similar observation has been made in the Thermocool study where early deaths were attributed to recurrence of VTs.[10] It needs to be emphasized that although ICDs are almost universal in this population, they can be inadequate in preventing arrhythmic deaths for various reasons including incessant VT, postdefibrillation electromechanical dissociation, and unsuccessful ICD discharges.[11] Not surprisingly, patients with VT recurrence have worse left ventricular function and more advanced heart failure compared with patients without recurrence, indicating a worse cardiac substrate. The relationship between heart failure exacerbation and worsening ventricular arrhythmias has been demonstrated in a MADIT II substudy (Multicenter Automatic Defibrillator Implantation Trial II) focusing on patients with a low ejection fraction.[12]

## Modification of Outcome Post Ablation

A key question is how to modify the grim prognostic outlook in patients with recurrent VT post ablation. In the current analysis, the time from VT recurrence to death or HTx was significantly longer in patients with recurrent VT who underwent repeat ablation than in patients who did not undergo repeat ablation. The 2 groups of patients had no significant identifiable differences in baseline characteristics, but the decision to proceed with a repeat ablation may have been influenced by unknown factors on a case-by-case basis, which may have also impacted outcomes. However, the difference in the time interval from VT recurrence to death or HTx among patients with versus those without repeat ablation suggests that repeat ablations may have a beneficial effect by altering the arrhythmogenic substrate and potentially preventing arrhythmia-related deaths. Prospective studies are necessary to clarify the effect of repeat ablation procedures on survival and whether early VT recurrence should impact on the decision making for earlier consideration of heart replacement therapies in patients with advanced cardiomyopathy.

### Limitations

The patient cohort of this analysis represents a referral population who underwent ablation procedures in experienced centers, thus generalizations should be made with caution. The use of antiarrhythmic medications such as amiodarone after ablation could have affected the prognosis, but information on compliance and length of use of such medications was not available for incorporation into the analyses. Similarly, the type of recurrent VT was not available (clinical versus new or nonclinical VT, type of symptoms, VT storm versus isolated VT, incessant VT, ICD shock, antitachycardia pacing, etc). We were unable to determine the cause of death in this large database because of the retrospective nature of the data acquisition. In addition, given the retrospective nature of the analysis, the effect of unmeasured confounders of the association between VT recurrence and mortality remains uncertain. Finally, some patients had ablation procedures at other institutions before the procedure that was considered to be the index ablation. The details of these previous procedures were not available. However, a history of ablation was not a predictor of VT recurrence or mortality. Also, only the effect of the first VT recurrence after the index ablation was examined, and it is unknown whether patients may have had subsequent recurrences after a repeat ablation.

### Conclusions

The impact of VT recurrence on adverse outcomes after ablation is highest early after ablation and decreases thereafter in a time-dependent manner. The timeline of VT recurrence and its impact on outcomes argue in favor of VT recurrences being the culprit for increased mortality early after ablation. Competing causes such as pump failure and comorbidities may play a more important role in adverse outcomes occurring later after ablation, and VT recurrence may constitute a marker rather than a cause of increased mortality. The role of repeat ablation needs to be investigated in an adequately powered prospective study to determine whether this can reduce mortality in patients with VT recurrence.

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**WHAT IS KNOWN**

- Recurrence of infarct-related ventricular tachycardia after catheter ablation is not uncommon and has been shown to adversely impact short-term and long-term prognosis.

**WHAT THE STUDY ADDS**

- The prognostic impact of ventricular tachycardia recurrence after ablation on mortality and heart transplantation is time dependent.
- Early recurrences are associated with the highest risk of adverse prognosis, and the risk decreases gradually with later recurrences.
- Repeat ablation after a recurrence may improve outcomes, but adequately powered, prospective studies are needed to better define the effect of repeat ablation.

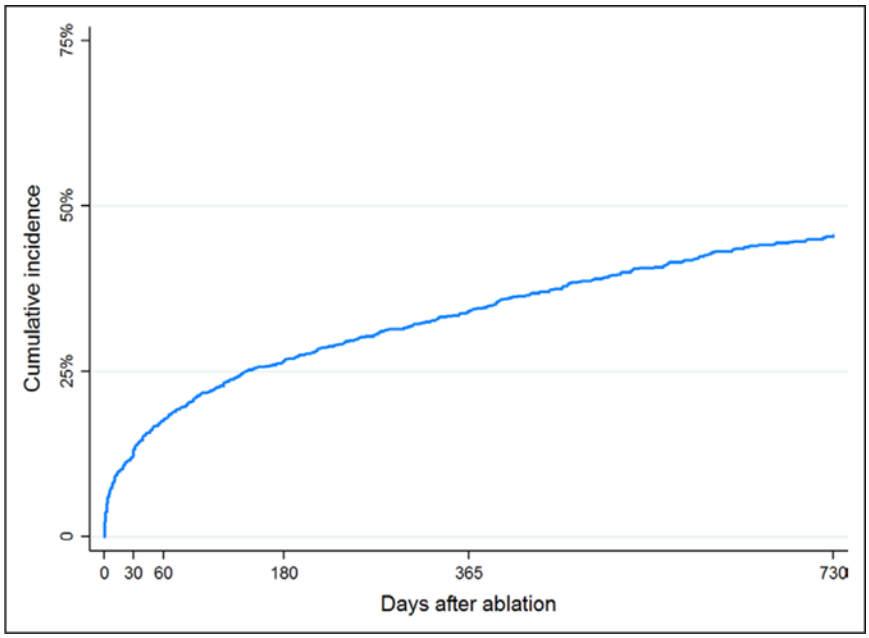


**Figure 1.**
Cumulative incidence of ventricular tachycardia (VT) recurrence after ablation, accounting for the competing risk of death before VT recurrence.

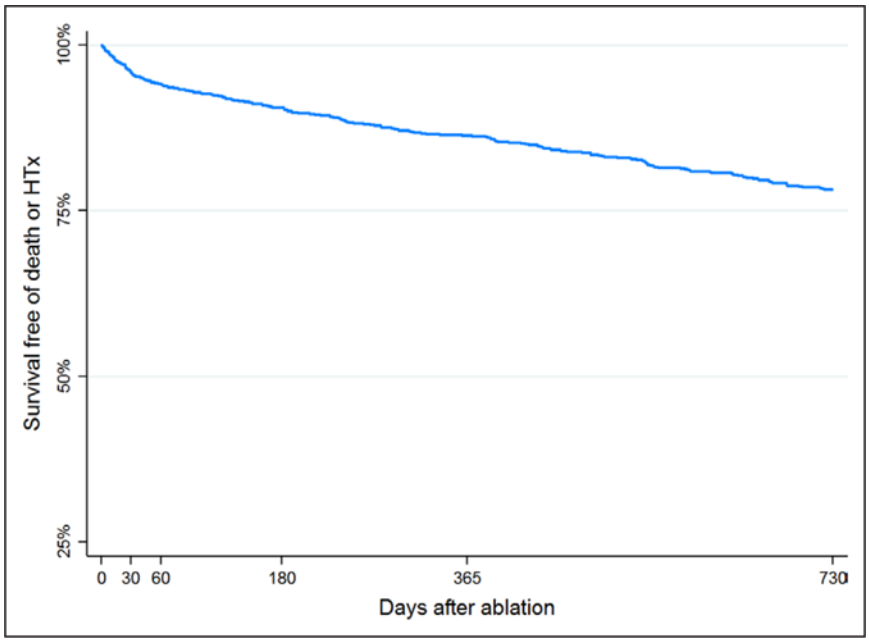


**Figure 2.**
Kaplan–Meier curve of survival free of death or heart transplantation (HTx).

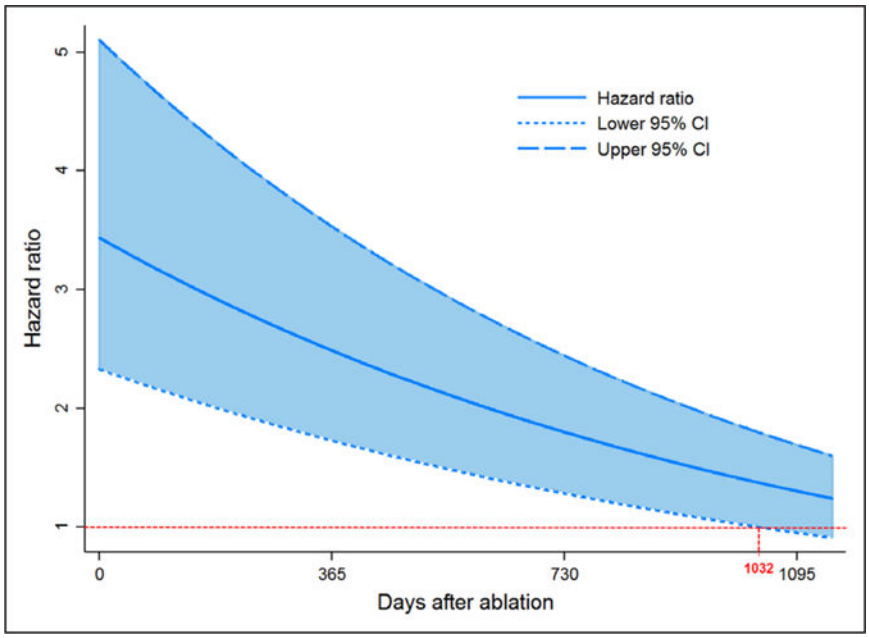


**Figure 3.**

Effect of ventricular tachycardia (VT) recurrence on death or heart transplantation (HTx) according to the timing of VT recurrence after ablation. Depicted is the change of the hazard ratio of the effect of VT recurrence on death or HTx as VT recurrence occurs at increasing follow-up after ablation. The adverse effect of VT recurrence becomes statistically nonsignificant on day 1032, when the lower confidence interval (CI) estimate crosses 1 for the first time.

## Table 1

Distribution of Baseline Demographic, Comorbidity, and Procedural Characteristics by VT Recurrence Status

| | Overall (n=1412) | VT Recurrence (n=605) | No VT Recurrence (n=807) | *P* Value |
|---|---|---|---|---|
| Age, y, median (IQR) | 68 (60.3–74) | 68 (60–74) | 69 (61–75) | 0.69 |
| Male sex, n (%) | 1306 (92.5) | 558 (92.2) | 748 (92.7) | 0.67 |
| Hypertension, n (%) | 994 (73.6) | 429 (75) | 565 (72.6) | 0.76 |
| Dyslipidemia, n (%) | 983 (72.6) | 436 (76.1) | 547 (70) | 0.054 |
| Diabetes mellitus, n (%) | 408 (29.5) | 198 (33.6) | 210 (26.5) | <0.001 |
| CKD, n (%) | 549 (39) | 246 (40.7) | 303 (37.6) | 0.21 |
| Atrial fibrillation, n (%) | 452 (34.9) | 199 (36.2) | 253 (33.9) | 0.08 |
| Previous ablation, n (%) | 250 (17.7) | 110 (18.2) | 140 (17.4) | 0.08 |
| LVEF, %, median (IQR) | 30 (22–40) | 28 (20–35) | 30 (24–40) | <0.001 |
| NYHA class, n (%) | | | | 0.005 |
| I | 245 (19.1) | 89 (16.1) | 156 (21.3) | |
| II | 575 (44.8) | 255 (46.1) | 320 (43.7) | |
| III | 408 (31.7) | 179 (32.4) | 229 (31.3) | |
| IV | 57 (4.4) | 30 (5.4) | 27 (3.7) | |
| CRT, n (%) | 436 (31.1) | 196 (32.7) | 240 (30) | 0.01 |
| VT storm, n (%) | 488 (34.8) | 236 (39.1) | 252 (31.6) | <0.001 |
| ICD shock, n (%) | 847 (67.4) | 371 (72.3) | 476 (64.1) | <0.001 |
| Previous amiodarone, n (%) | 820 (59) | 365 (61.1) | 455 (57.5) | 0.26 |
| Noninducible at beginning, n (%) | 157 (11.4) | 49 (8.3) | 108 (13.7) | 0.08 |
| Procedure time, min, median (IQR) | 219 (160–300) | 210 (160–280) | 232.5 (164–320) | 0.17 |
| RF time, min, median (IQR) | 34 (19.9–54.6) | 34.7 (20.1–54.3) | 32.9 (19.6–55.5) | 0.22 |
| Ablation type, n (%) | | | | |
| Endocardial | 1260 (91.3) | 547 (91.9) | 713 (90.8) | Reference |
| Epicardial | 14 (1) | 7 (1.2) | 7 (0.9) | 0.81 |
| Both | 106 (7.7) | 41 (6.9) | 65 (8.3) | 0.51 |
| No. of clinical VTs, median (IQR) | 1 (1–1) | 1 (1–2) | 1 (1–1) | 0.052 |
| No. of induced VTs, median (IQR) | 2 (1–4) | 2 (1–4) | 2 (1–3) | 0.06 |
| Procedural success status, n (%) | | | | |
| Complete | 835 (68.4) | 308 (62.1) | 527 (72.8) | Reference |
| Partial | 259 (21.2) | 123 (24.8) | 136 (18.8) | <0.001 |
| Failure | 63 (5.2) | 35 (7.1) | 28 (3.9) | <0.001 |
| Not tested | 63 (5.2) | 30 (6) | 33 (4.5) | 0.006 |
| Discharge amiodarone, n (%) | 544 (42.7) | 252 (46.8) | 292 (39.7) | 0.001 |
| Discharge class 1 AAD, n (%) | 127 (10) | 72 (13.4) | 55 (7.5) | <0.001 |
| Discharge sotalol, n (%) | 150 (11.8) | 66 (12.3) | 84 (11.4) | 0.84 |
| Discharge β-blocker, n (%) | 1109 (80.9) | 482 (82.5) | 627 (79.7) | 0.95 |

*P* values are from Cox regression models with a single predictor or a set of indicators for a categorical variable such as ablation type. AAD indicates antiarrhythmic drug; CKD, chronic kidney disease; CRT, cardiac resynchronization therapy; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; RF, radiofrequency energy; and VT, ventricular tachycardia.

## Table 2

Distribution of Baseline Demographic, Comorbidity, and Procedural Characteristics by the Composite End Point of Death or HTx Status

| | Death or HTx (n=375) | No Death or HTx (n=1037) | *P* Value |
|---|---|---|---|
| Age, y, median (IQR) | 71 (64–77) | 67 (59–73) | <0.001 |
| Male sex, n (%) | 345 (92) | 961 (92.7) | 0.88 |
| Hypertension, n (%) | 275 (76.2) | 719 (72.7) | 0.94 |
| Dyslipidemia, n (%) | 267 (74) | 716 (72.1) | 0.75 |
| Diabetes mellitus, n (%) | 142 (38.6) | 266 (26.2) | <0.001 |
| CKD, n (%) | 183 (48.8) | 366 (35.3) | <0.001 |
| Atrial fibrillation, n (%) | 146 (42.8) | 306 (32) | <0.001 |
| Previous ablation, n (%) | 62 (16.5) | 188 (18.1) | 0.56 |
| LVEF, %, median (IQR) | 25 (20–33) | 30 (25–40) | <0.001 |
| NYHA class, n (%) | | | <0.001 |
| I | 33 (9.7) | 212 (22.4) | |
| II | 119 (35) | 456 (48.3) | |
| III | 156 (45.9) | 252 (26.7) | |
| IV | 32 (9.4) | 25 (2.6) | |
| CRT, n (%) | 150 (40) | 286 (27.8) | <0.001 |
| VT storm, n (%) | 160 (42.8) | 328 (31.9) | <0.001 |
| ICD shock, n (%) | 221 (67.8) | 626 (67.3) | 0.65 |
| Noninducible at beginning, n (%) | 29 (7.9) | 128 (12.6) | 0.61 |
| Procedure time, min, median (IQR) | 222 (169.5–333) | 216 (160–300) | 0.14 |
| RF time, min, median (IQR) | 34.6 (20.5–55.6) | 33.7 (19.3–54.4) | 0.81 |
| Ablation type, n (%) | | | |
| Endocardial | 341 (92.7) | 919 (90.8) | Reference |
| Epicardial | 2 (0.5) | 12 (1.2) | 0.30 |
| Both | 25 (6.8) | 81 (8) | 0.58 |
| No. of clinical VTs, median (IQR) | 1 (1–1) | 1 (1–1) | 0.24 |
| N induced VTs, median (IQR) | 2 (1–4) | 2 (1–3) | 0.20 |
| Procedural success status, n (%) | | | |
| Complete | 193 (61) | 642 (71) | Reference |
| Partial | 78 (24.7) | 181 (20) | 0.12 |
| Failure | 26 (8.2) | 37 (4.1) | <0.001 |
| Not tested | 19 (6) | 44 (4.9) | 0.26 |
| Discharge amiodarone, n (%) | 21 (6.3) | 129 (13.8) | <0.001 |
| Discharge class 1 AAD, n (%) | 46 (13.7) | 81 (8.7) | 0.006 |
| Discharge sotalol, n (%) | 289 (82.3) | 820 (80.3) | 0.44 |
| Discharge β-blocker, n (%) | 195 (58.2) | 349 (37.2) | <0.001 |

*P* values are from Cox regression models with a single predictor or a set of indicators for a single categorical variable such as ablation type. AAD indicates antiarrhythmic drug; CKD, chronic kidney disease; CRT, cardiac resynchronization therapy; HTx, heart transplantation; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; RF, radiofrequency energy; and VT, ventricular tachycardia.

## Table 3

Adjusted Hazard Ratios of the Effects on Death or Heart Transplantation Based on Cox Regression Analysis

| Covariate | HR (95% CI) |
|---|---|
| Age (per y) | 1.04 (1.02–1.05) |
| Male sex | 0.97 (0.58–1.61) |
| Diabetes mellitus | 1.51 (1.14–1.98) |
| Atrial fibrillation | 1.36 (1.04–1.79) |
| Chronic kidney disease | 1.11 (0.85–1.45) |
| LVEF (per 1% increase) | 0.97 (0.95–0.98) |
| NYHA class (per advancing class) | 1.44 (1.20–1.72) |
| CRT | 1.08 (0.81–1.43) |
| VT storm | 1.07 (0.82–1.41) |
| ICD shock | 0.77 (0.58–1.03) |
| Procedural success status | |
| Complete | Reference |
| Partial | 1.30 (0.96–1.78) |
| Failure | 2.49 (1.51–4.10) |
| Not tested | 2.08 (1.19–3.64) |
| VT recurrence | |
| On day 0 | 3.45 (2.33–5.11) |
| On day 7 | 3.43 (2.32–5.07) |
| On day 30 | 3.36 (2.29–4.93) |
| On day 180 | 2.94 (2.09–4.14) |
| On day 365 | 2.50 (1.85–3.37) |
| On day 730 | 1.81 (1.37–2.40) |
| On day 1032 | 1.39 (0.99–1.93) |

The model included the interactiqn term of VT recurrence by time after ablation that was significant with the adjusted HR of 0.9991175 (95% CI, 0.9986725–0.9995626) per day or 0.973861 (95% CI, 0.9609322–0.9869609) per 30 d. The HR associated with VT recurrence on a specific day post ablation was calculated with the following formula: HR on day t=(HR on day 0)×(HR per day)$^{t}$=3.45×0.9991175$^{t}$. CI indicates confidence interval; CRT, cardiac resynchronization therapy; HR, hazard ratio; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; and VT, ventricular tachycardia.